AUTOMATION AND OPTIMIZATION LABRATORY

# Path Planning with Power Schedules for Solar-Powered Ground Robot

## Optimization Method, Types of Path Plans, Test Environment Setup and Evaluation, and Future Work

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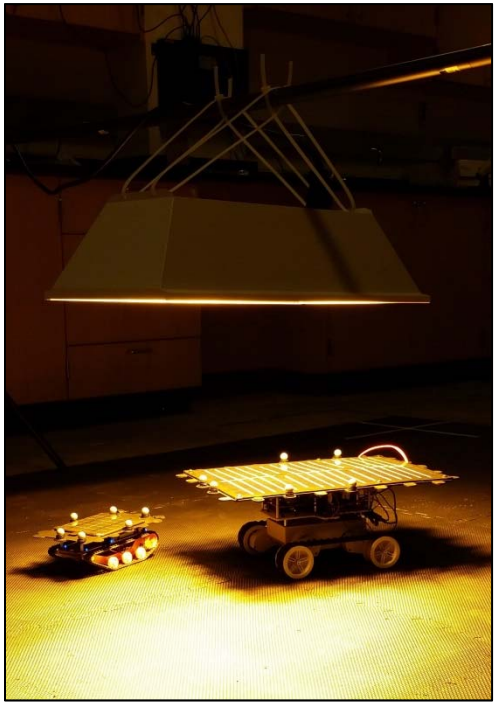
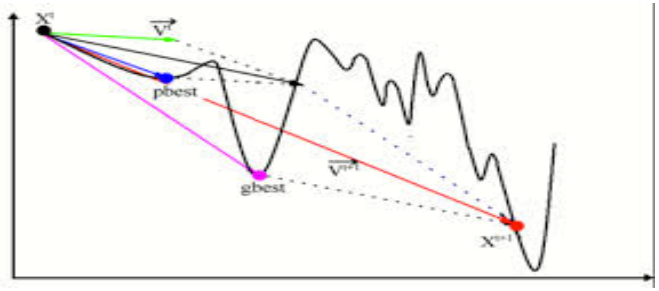
# Objective

Minimize the travel time of a solar-powered, unmanned, ground vehicle through an area with no net energy loss

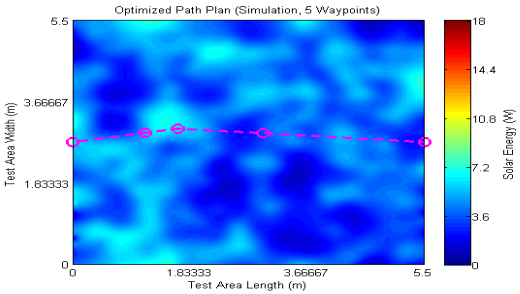


# Modified Particle Swarm Optimization

- Non-uniform solar radiation distributions
- Particle Swarm Optimization (PSO) creates a number of candidate solutions or particles
  - It is an iterative process
  - After each iteration, the particles are evaluated and compared to each particle's best recorded parameters and the group's best.
  - Each particle is comprised of the vehicle's waypoint locations, linear velocities, and rotational velocities at each turn.
- Constraints of the Problem
  - Negligible Net Energy Loss over path
  - Minimize Travel Time




**Graphical Representation**

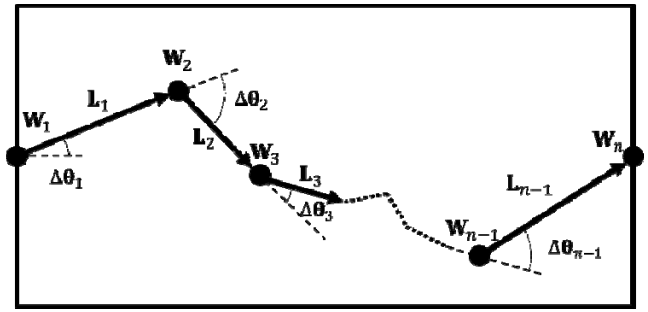



**Example Motion Plan**

# Types Of Path Plans

## Balkcom-Mason

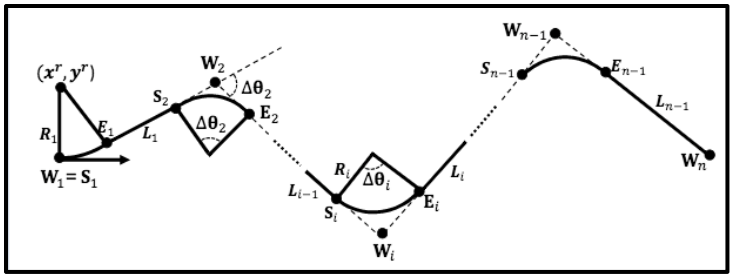
- Governed by three differential – drive primitives
  - Forward, clockwise, and counterclockwise rotation




**Example of Balkin-Mason Path Planning**

## Pseudo-Dubin

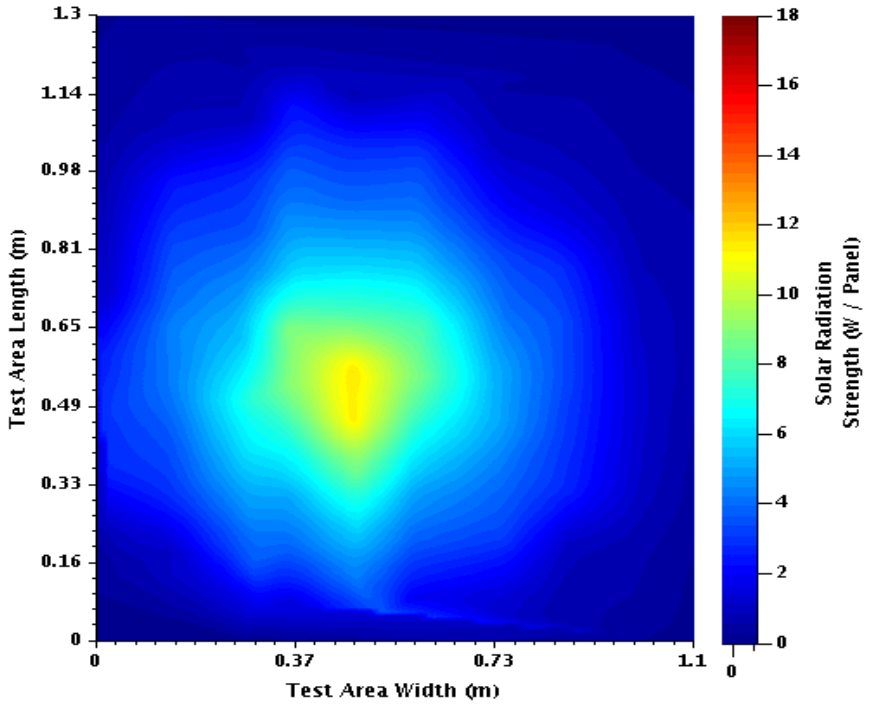
- Derived from Dubin Curves
- Characterized by variable turn radius and continuous differential drive
  - Allows for forward and circular arc turns



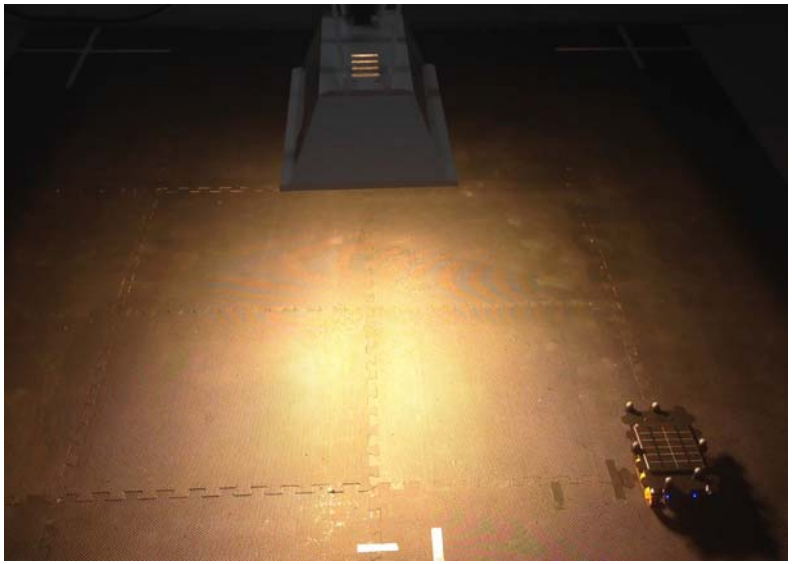

**Example of Pseudo-Dubin Path Planning**

# Solar Energy Map Example

The solar energy density produced by a single light is sampled and generated into a scalar field.



# Solar Energy Map Example



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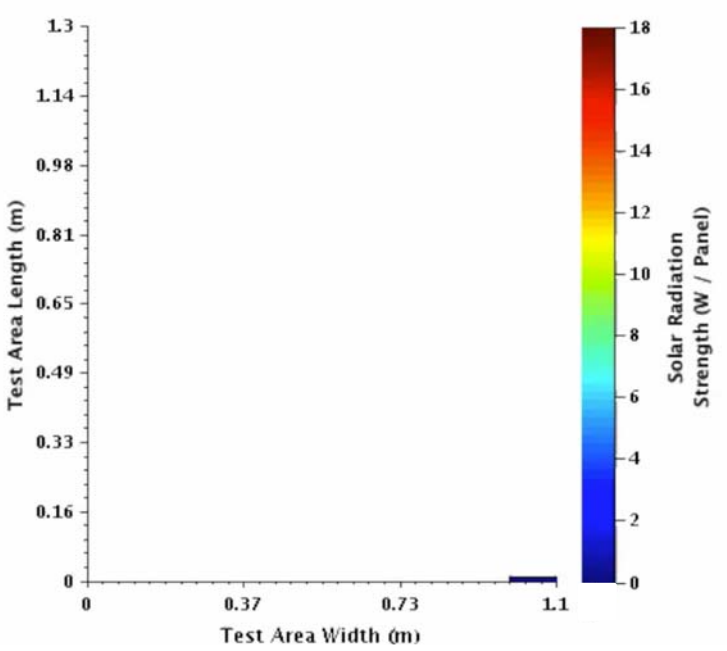
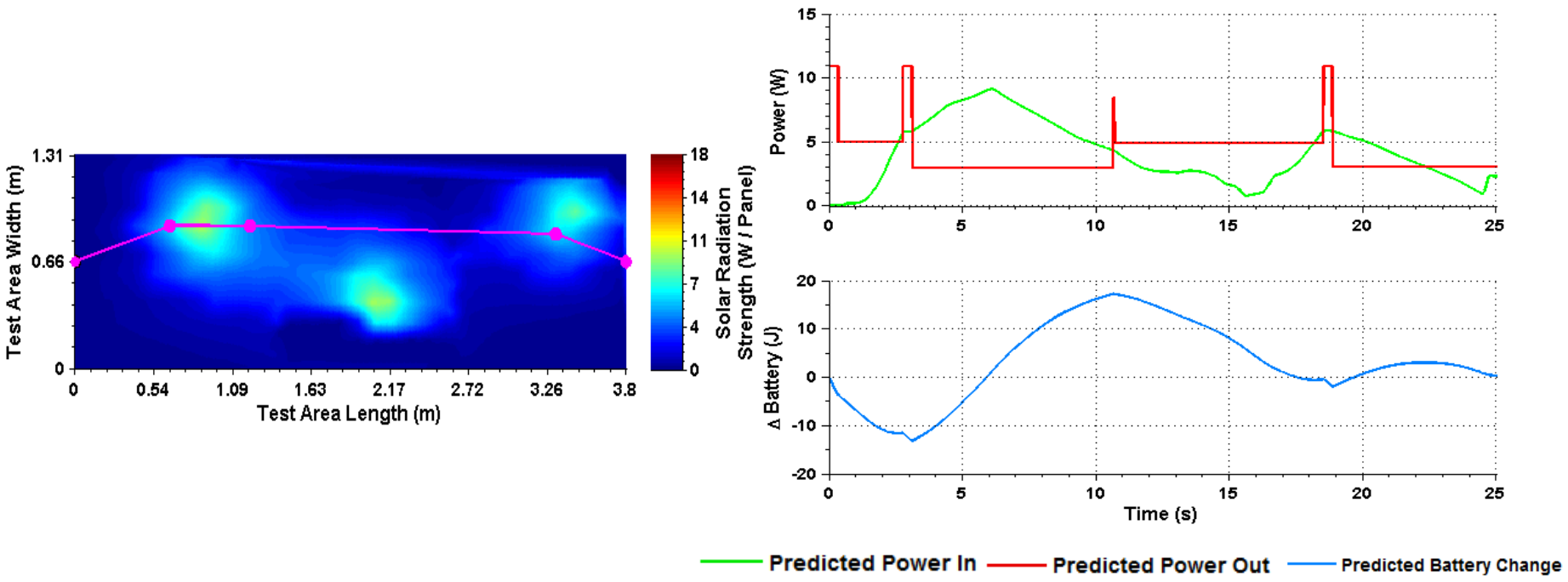


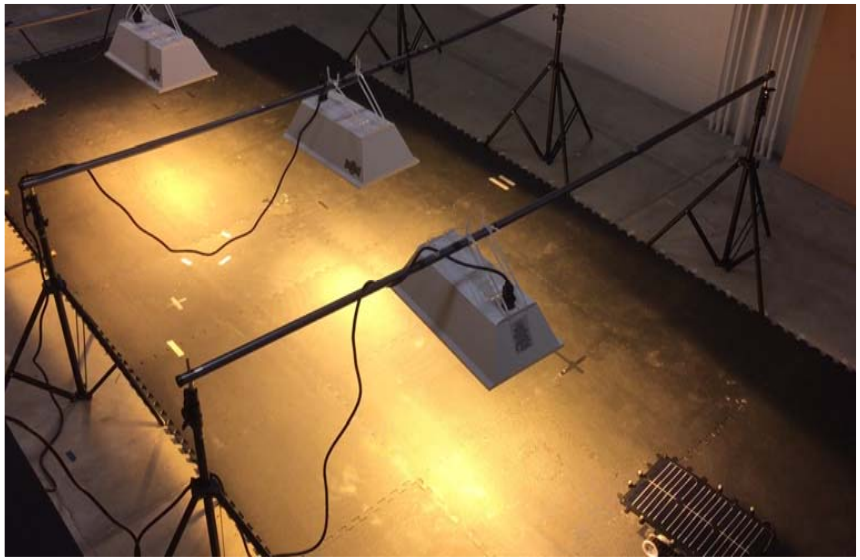
# Balkcom-Mason Motion Plan Example

A three light environment is navigated with negligible net energy change using a Balkcom-Mason motion plan produced from our modified heuristic optimizer.

# Balkcom-Mason Motion Plan Example



# Balkcom-Mason Motion Plan Example



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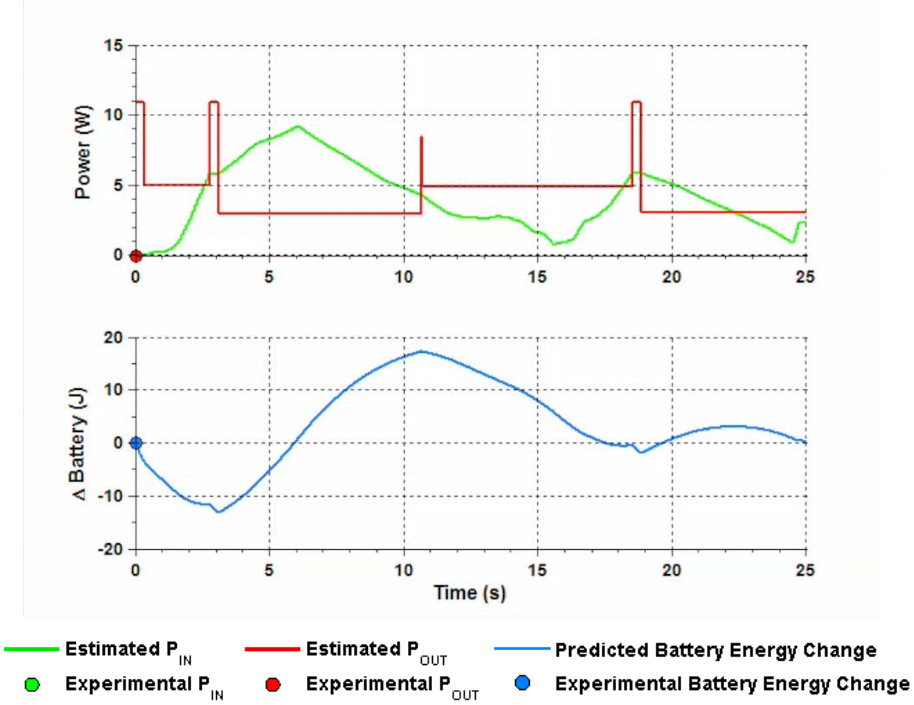
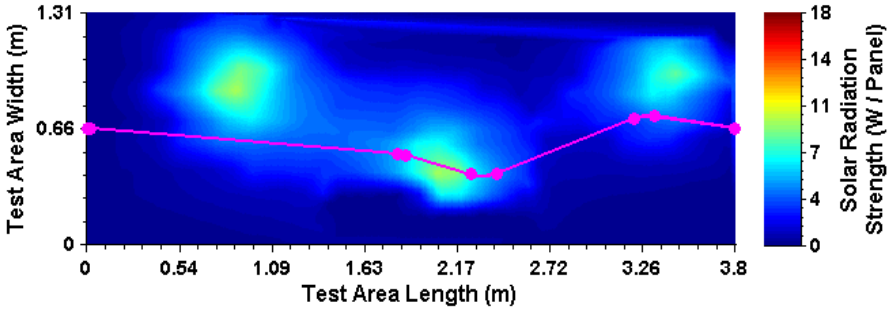
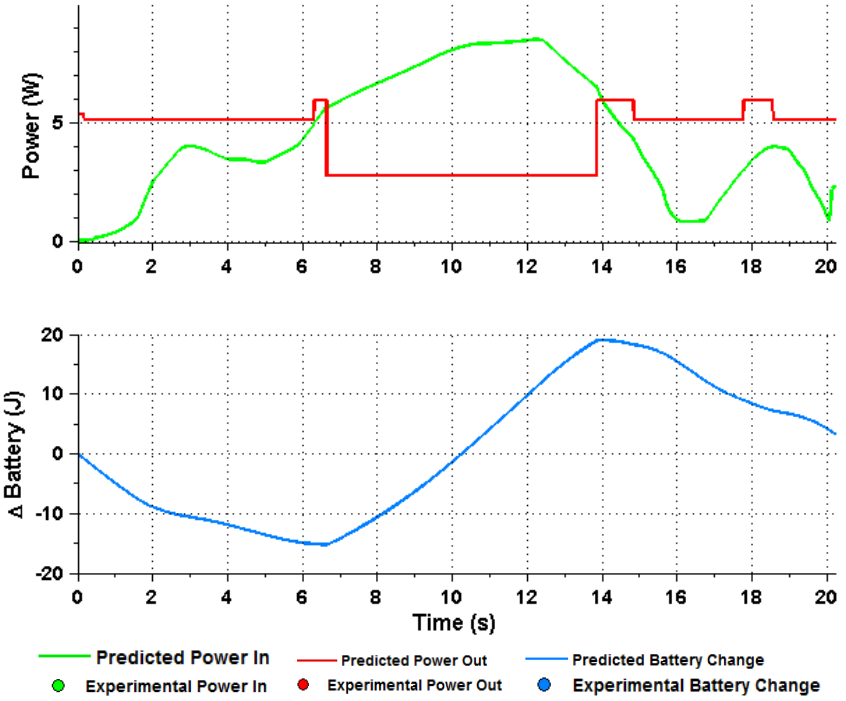


# Pseudo-Dubin Motion Plan Example

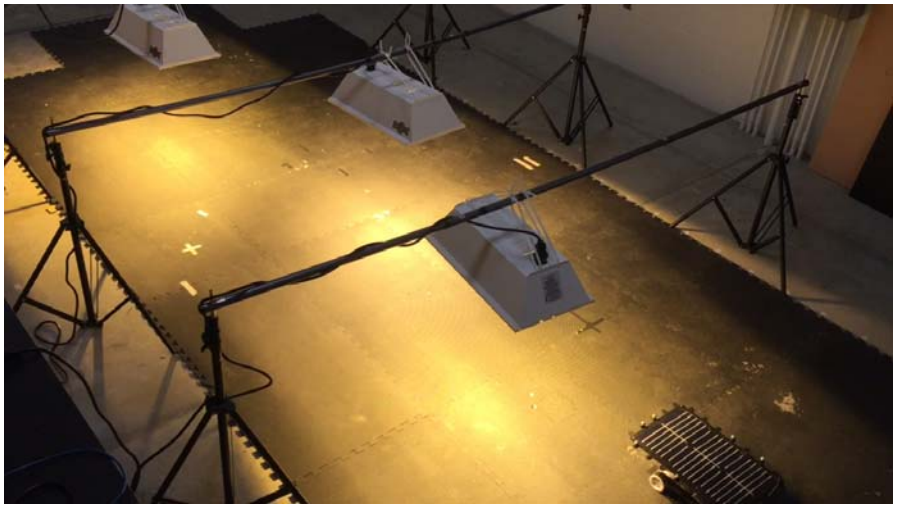
The three light environment is now navigated with negligible net energy change using the previous waypoints and a Pseudo-Dubin motion plan.

# Pseudo-Dubin Motion Plan Example



# Pseudo-Dubin Motion Plan Example



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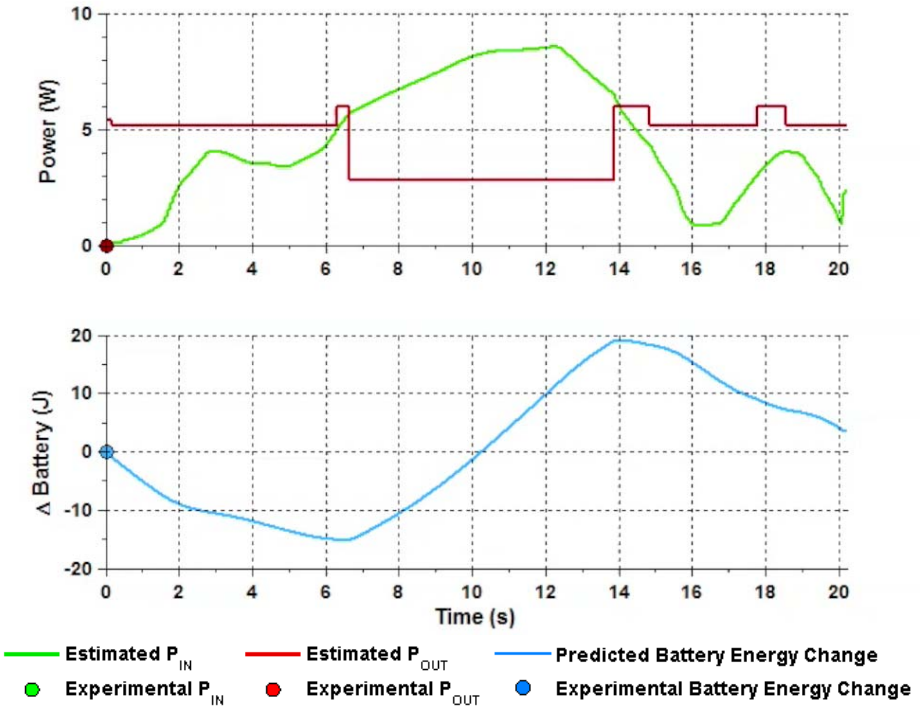
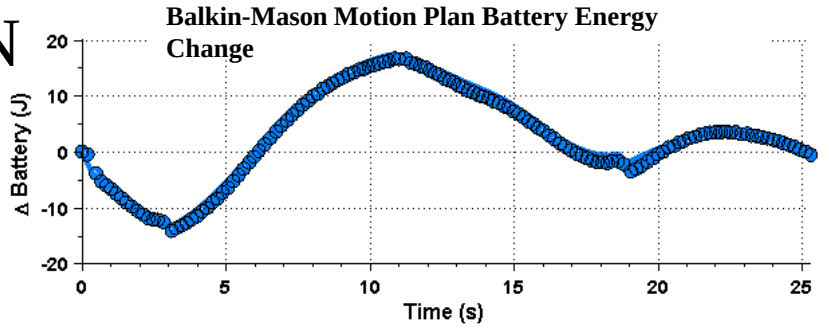


# Motion Plan Results

## Balkcom-Mason Motion Plan

Time: 25.22 s

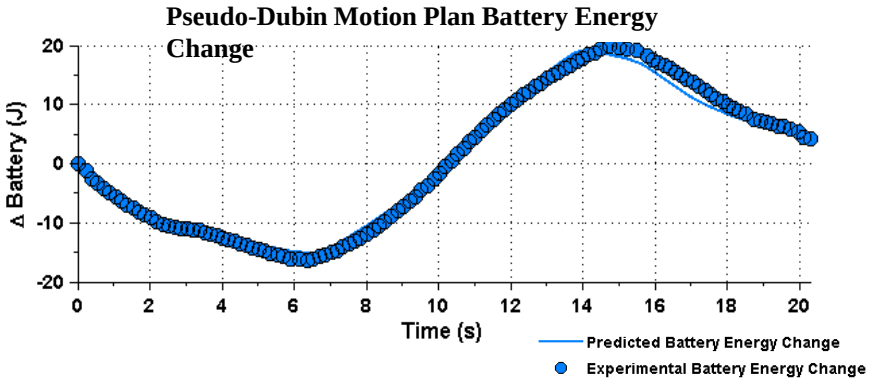
Final Battery Energy: -0.56 J




## Pseudo-Dubin Motion Plan

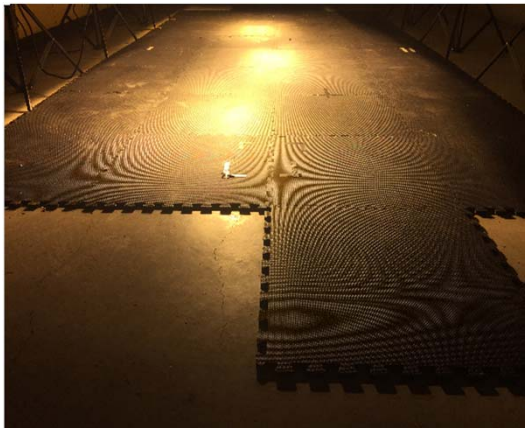
Time: 20.12 s

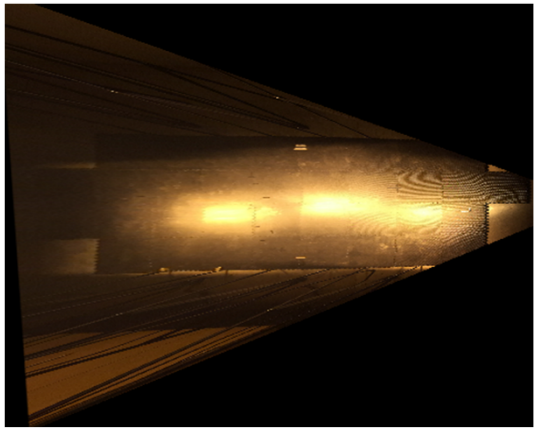
Final Battery Energy: +3.67 J

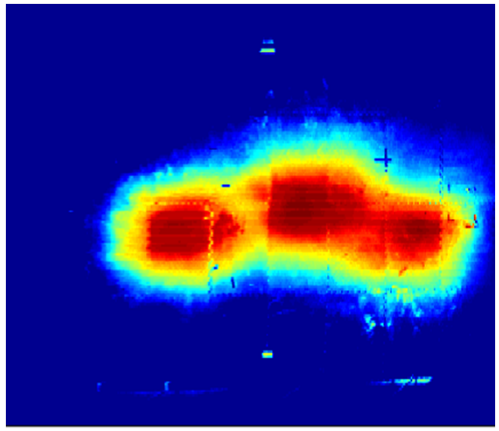



## Time Reduction: **20.22%**

# Future Work: Visual Light Denisty Mapping







Benefits:

- Have knowledge of an area before entering
- Faster and more efficient than current point-based data gathering approach
- Allows for snap-shots of Time-Variant areas.